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Edjabou, Maklawe Essonanawe; Boldrin, Alessio; Scheutz, Charlotte; Astrup, Thomas Fruergaard

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Generation of organic waste from institutions in Denmark: case study of the Technical University of Denmark

Maklawe Essonanawe Edjabou, Alessio Boldrin, Charlotte Scheutz, Thomas Fruergaard Astrup,
Department of Environmental Engineering, Technical University of Denmark

Contact: Maklawe Edjabou, 2800 Kgs. Lyngby, Denmark, +45 3195 9933, vine@env.dtu.dk

EXECUTIVE SUMMARY

As a response to the growing pressure on the supply chains, developing a resource-efficient circular economy will be fundamental to satisfy the future demands for material resources. In this context, the Danish Government, in 2013, launched its Resource Strategy Plan, mandating that, by 2018 at least 60% of organic waste – that cannot be prevented or reduced –generated by service sector, should be source-segregated and collected separately. In order to establish the baseline of the current situation, and to allow for any evaluation of performance against target indicators, data on solid waste generation and composition are required.
The overall aim of this study was to quantify the potential for source-segregated organic waste as well as mixed waste from institution.

This study was carried at the Department of Environmental Engineering at Technical University of Denmark. In the course of this study, two plastic waste bins of 60 L each were placed in the kitchens: organic waste bins and mixed waste bins. Organic waste and mixed waste from these kitchens were collected and weighed separately, on a daily basis, during 133 working days (29 weeks). However, waste was not sampled during weekends and public holidays, when the offices were officially closed. Furthermore, the composition of source-segregated organic waste was analysed to investigate its purity.

During the sampling period, the number of employees coming to work at the department was recorded. These data were used to investigate any relationship between mass of discarded waste (source-segregated organic and mixed waste) and the number of employee coming to work at the department.

The result showed that 20 to 60 days (e.g. working days) should be considered to obtain reliable data when sampling waste from an institution.
We found a significant correlation between mass of source-segregated organic waste and the number of employees coming to work at the department (0.70 with 95% HDI 0.6 and 0.78). Similarly, there was a significant correlation between mixed waste and number of employees (0.49 with 95% HDI 0.3 and 0.62).
The generate rates of source-segregated organic waste amounted to 23 ± 5 kg/employee/year, of which 20 ± 5 kg/employee/year was source-segregated, with a considerably high purity of 99%. Mixed waste amounted to 10 ± 5 kg/employee/year.
These results show that source-segregated organic waste from institutions offers promising potential. They also suggest that recycling target for source-segregated organic waste might be achievable with reasonable logistical ease in institution areas.

1 INTRODUCTION

1.1 Background

As a response to the growing pressure on the supply chains, developing a resource-efficient circular economy will be fundamental to satisfy the future demands for material resources. In this context, the Danish Government, in 2013, launched its Resource Strategy Plan, mandating that, by 2018 at least 60% of organic waste – that cannot be prevented or reduced –generated by service sector, should be source-segregated and collected separately.
In order to establish baselines, set objectives and track progress toward targets indicators, data on solid waste generation and composition are crucial.
Numerous studies have focused on residual household waste (Edjabou et al., 2015b; Riber et al., 2009), organic and organic waste from household (Lebersorger & Schneider, 2011). However, data on organic waste from institutions are very limited (Christensen & Fruergaard, 2010), despite their importance. Importantly, few studies have attempted to investigate the feasibility of the current Resource Strategy Plan launched by the Danish Government (Danish Government, 2015). This study aims at filling these identified knowledge gaps.

1.2 Research objectives

The overall goal of this study was to quantify the potential for source-segregated organic waste from institution. This objective was achieved by investigating the mass of source-segregated organic waste as well mixed waste discarded by employees. Furthermore, we investigated sample size that should be considered to attain reliable waste data and representative waste sample.

2 METHODOLOGY

The study was carried out at the Department of Environmental Engineering at the Technical University of Denmark. Here, there is a long tradition to source segregate following waste fractions: paper, board, glass, plastic packaging, metal, hazardous waste, batteries, and WEEE.
For the purpose of this study, employees were asked to sort their chicken waste into organic and mixed waste. Organic waste consists of avoidable food waste, unavoidable food waste, spent coffee ground, flowers, filters, tea bags, etc. Mixed waste includes all waste a part from organic waste and traditional source-segregated fractions, such as tissue paper, plastic film, food wrapping paper, aluminium wrapping foil, etc. Thus, two waste bins were placed in each of the four kitchens: (1) organic waste bin and (2) mixed waste bin. Guidelines and other information regarding sorting were available on website. Additionally, information meeting was held to ensure face to face explanation before the waste sorting campaign.
The waste from each kitchen was collected and weighed on daily basis during weekdays. However, the waste was not sampled during weekends and public holidays because the institution is officially closed.
The study was carried out during 133 working days, corresponding to 29 weeks.
Data attained was statistically analysed. We used Bayesian correlation test to assess the correlation between waste generation and number of employees (Kruschke, 2012). The statistical analyses were modelled in the statistical and graphical programming language R (http://www.r-project.org)

3 RESULTS AND DISCUSSION

3.1 Sample size

The sample size refers to the number of days of waste sampling. The representativeness of the number of sampling days was assessed by comparing three confidence intervals including (1) bootstrap, (2) t-distribution, and (3) normal distribution as a function of sample size, given a fixed standard deviation (Crawley, 2005). The result is shows in Figure 1 for source-segregated organic waste. As shown in Figure 1, confidence intervals declined considerably when the number of working days increased. These results suggest that 133 working days was considerable large sample size. Furthermore, 20 to 60 working days may be considered as acceptable sample size to generate reliable data.

3.2 Mass of source-segregated organic and mixed waste

Mass of source-segregated organic waste and mixed waste generated during 133 working days is shown in Figure 2. From the data in Figure 2, the generation of organic waste and mixed waste fluctuated considerably during 133 working days. The generation of organic waste reached its first peak in March and the second in May. One reason of these peaks is discarded food waste from clean out employees' ´fridge before holidays. Indeed, highest mass of organic waste was recorded just before Easter and summer holidays. Moreover, the mass of organic waste declined considerably in July

and bottomed out in the beginning of August as a consequence of summer holiday. This is owned to most of employees go on holidays in July. Henceforth, the mass of source-segregated organic waste increased progressively to reach it level before July, when employees returned from holidays. On the contrary, mass of mixed waste reached its only peak in the beginning of July, although it decreased considerably afterwards.

3.3 Correlation between number of employees at work and waste

Bayesian correlation between the number of employees coming to work at the department and the mass of source-segregated organic waste is shown in Figure 3. The correlation coefficient was 0.70 and was statistically significant with 95% high density interval (HDI) from 0.6 to 0.78. This suggests that there is a significant relationship between the number of employees and the mass of source-segregated organic waste. Furthermore, the positive correlation coefficient suggests that the mass of source-segregated organic waste increases in line with the number of employees coming to work at the Department. These results explained consistently the waste generation pattern observed in Figure 2. Similarly, there was also a positive and significant correlation between mixed waste and number of employees coming to word at the department 0.49 with 95% HDI from 0.35 to 0.62. However, it is moderate correlation coefficient.

3.4 Waste generation rates

Based on the correlation test, we estimated the waste generation rates. The potential of organic was 23 ± 5 kg/employee/year. However, the source-segregated organic waste collected amounted to 20 ± 5 kg/employee/year corresponding to a sorting efficiency of 89% (Edjabou et al., 2015a).

Composition analysis revealed that source-segregated organic waste contained about 1% of impurity consisting of misplaced plastic foil into organic waste bin.

This result indicates that the target of collection and biologically processing of organic waste that cannot be avoided may be achievable.

Although the generation rate of source-segregated organic waste is lower than average organic waste generated from households (75 kg per person per year) (Edjabou et al., 2013), the purity of source-segregated organic waste from institutions is far higher than those of households. As a result, the sorting efficiency of organic waste from institution (89%) is higher than this found in household (35%) (Edjabou et al., 2015a).

Furthermore, given that the average household size is extremely lower than institutions; significant mass of organic waste could be collected separately with reasonable logistical. For example, we used only eight waste bins to collect 8 kg /working day of source-segregated organic waste and 4 kg /working day of mixed waste.

4 CONCLUSIONS

This study quantified the source-segregated organic waste from institution. The results showed that the recycling rate target for source-segregated organic waste could be achievable with reasonable logistical. Moreover, the quality of source-segregated organic waste from institutions areas found to be extremely high.

5 ACKNOWLEDGEMENTS

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Figure

FIGURE 1 **Evaluation of number of sampling day for organic waste**

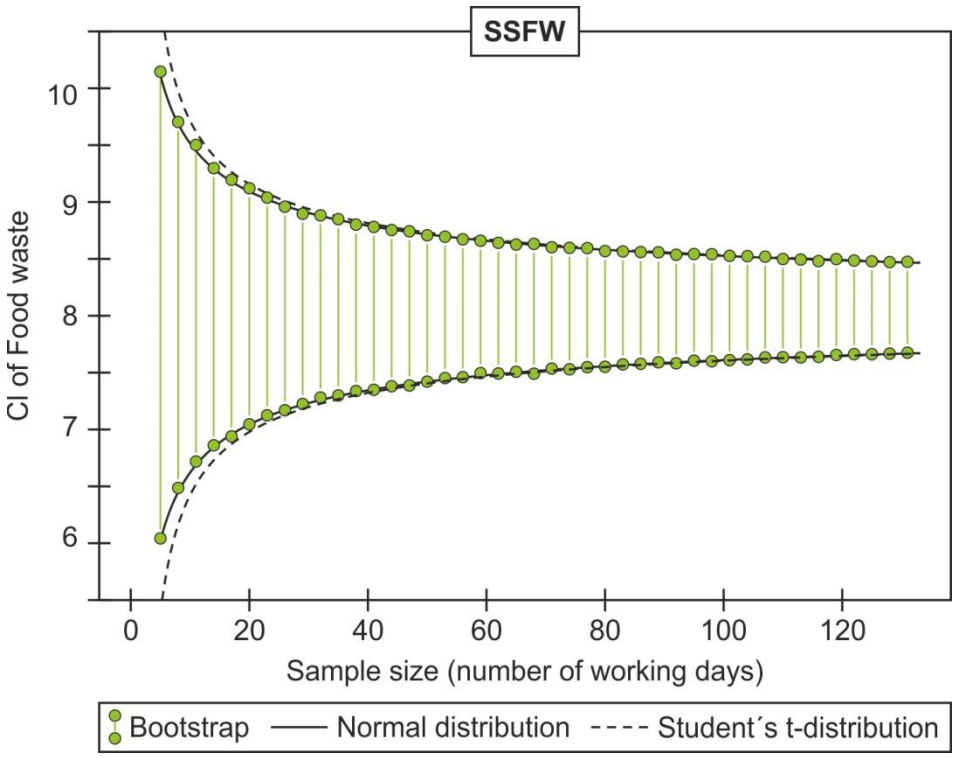


FIGURE 2 **Evaluation of number of sampling day for Mixed waste**

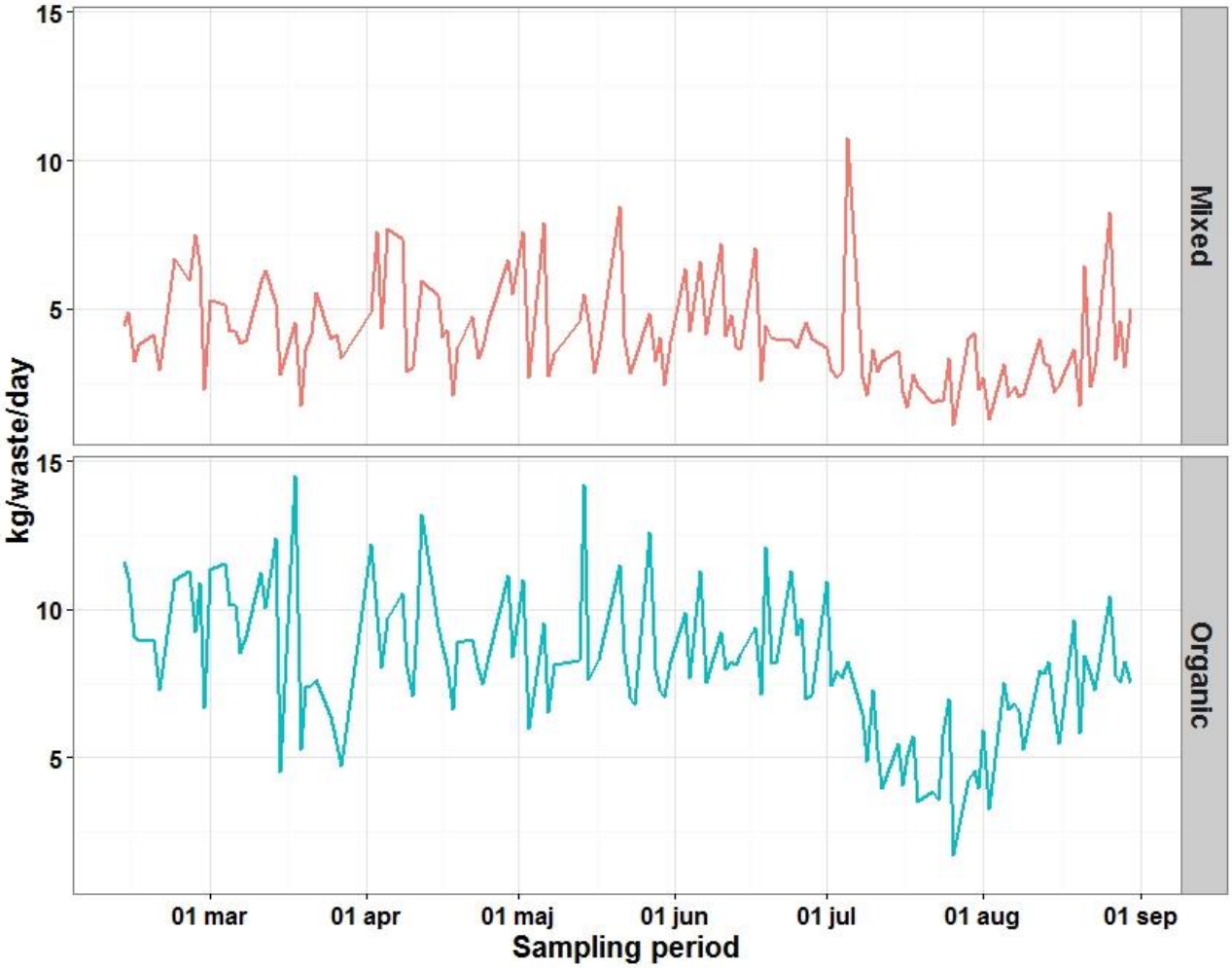
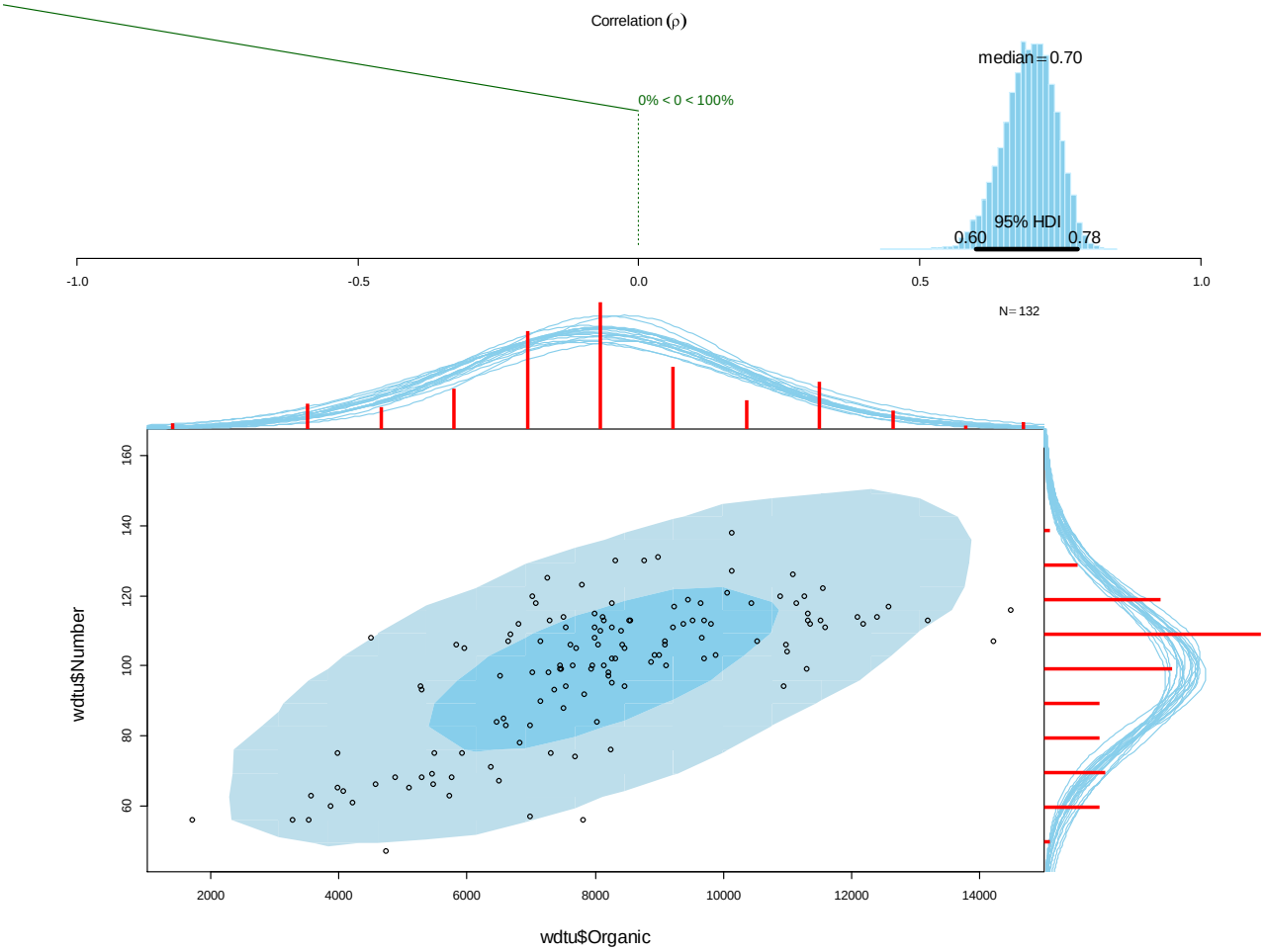


FIGURE 3 **Correlation between number of employees and mass of source-segregated organic waste**



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